

EXPLORING ELECTRONICS LABORATORY EXPERIMENTS USING COMPUTER SOFTWARE

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ABSTRACT

The roles of teachers and students are changing, and there are undoubtedly ways of learning not yet discovered. However, the computer and software technology may provide a significant role to identify the problems, to present solutions and life-long learning. It is clear that the computer based educational technology has reached the point where many major improvements can be made, and significant cost reductions can be achieved, specifically in the area of Science education. In science, the full-course (lecture. laboratory component) may replace the existing lecture-based courses, and the virtual instruments may provide a highly interactive user interface and advanced analysis facilities that were not deliverable in the conventional methods. The user-friendly GUI may provide a better scientific picture of the system under test. Moreover, using distance learning may attract new students and add value to education. Equipping the laboratories with effective education tools can empower both the disciplines and the students. Hence, the effectiveness of the laboratory course in imparting knowledge increases and it enables the students to absorb the role of individual science disciplines and addresses the real problems. It is clear that change is necessary because many of the things that we are doing can be done better with the help of technology. Although the initial cost may be high, if the right technology is selected continuous improvement can be achieved with minimal cost. The cost of the development may be reduced further if the portion of the existing hardware is utilized and integrated with the existing system. If the size and the complexity of the system increase, organizations and universities may undertake laboratory developments in partnership with other universities and/or commercial partners.

Keywords: Laboratory practical's, Computer Software, Simulation, Virtual Instrumentation.

INTRODUCTION

In recent years, electronics the world over has made unprecedented growth in terms of new technologies, new ideas and principles. The rate of obsolescence of technologies also has been extremely high. Researchers, academicians, industries and the society at large have to work in unison to meet the challenges of the rapidly growing discipline. The research organizations and industries that work in this frontier area are in need of highly skilled and scientifically oriented manpower. This manpower can be available only with flexible, adaptive and progressive training programs and a cohesive interaction among the research organizations, academicians and industries.

Laboratory activities must be designed to engage students' minds, so that students may acquire skill and confidence in their:

- Measurement of physical quantities with appropriate accuracy.
- Recognition of factors that could affect the reliability of their measurements.
- Manipulations of materials, apparatus, tools, and measuring instruments.
- Clear descriptions of their observations and measurements
- Representation of information in appropriate verbal, pictorial, graphical, and mathematical terms
- Inference and reasoning from their observations
- Ability to rationally defend their conclusions and predictions
- Effective and valued participation with their peers and their teacher in a cooperative intellectual enterprise

- Articulate reporting of observations, conclusions, and predictions in formats ranging from
- Informal discussion to a formal laboratory report
- Ability to recognize those questions that can be investigated through experiment and to plan carries out, evaluate, and report on such experiments.

Laboratory work is essential in the study of electronics. Electronics is a laboratory-based course designed to expose students to basic analog and digital devices and circuits. Students are encouraged to discover concepts through laboratory experiences and apply their knowledge to problems and projects.

Laboratory work should aim to encourage students to gain

- Manipulative skills
- Observational skills
- The ability to interpret experimental data
- The ability to plan experiments
- Interest in the subject
- Enjoyment of the subject
- A feeling of reality for the phenomena talked about in theory

The laboratory experiments should help students master basic electronics concepts, should help students understand the role of direct observation in electronics and to distinguish between inferences based on theory and the outcomes of experiments.

Theory and research suggest that meaningful learning is possible in laboratory activities if all students are provided with opportunities to manipulate equipment and materials while working cooperatively with peers in an environment in which they are free to pursue solutions to problems that interest them. Effective and appropriate experimentation is often seen as a highly significant component of an undergraduate science based curriculum. Third level institutions are under pressure to keep up to date with commercial advances and technology; so that students graduating from their courses have the necessary skills to operate in a competitive business environment [1]. However indications are that due to the high cost involved in upgrade and maintenance of equipment, that there has

been a decline in the emphasis placed on experimentation in engineering courses in recent decades [2]. Institutions attract new students to their courses by making them interesting, comprehensive and relevant to industrial applications and the majority of graduates either continue within academia or take up employment in their chosen discipline. In both, research and industrial applications, it is commonplace to use a computer for data acquisition. Students that have not gained experience in automated systems during their course work are disadvantaged both in acquiring and performing the duties required. Virtual instrumentation can help not only the students but the faculties themselves by recreating the equivalent of very expensive conventional laboratory equipment quite cheaply [3]. Through the use of a Data Acquisition (DAQ) tools, students can record relevant data from the experiments in real time. This allows students to concentrate on the concepts and details of experiment itself and not get distracted by the process of data recording. Animations, images and video clips can also be embedded within the virtual instrument which engage students and give them real world examples that relate to their coursework. Students can thereby gain not only a better understanding of *what* they are doing but *why* they are doing it [3].

One of the recurring advantages attributed to using computers in the classroom is that of more positive student attitudes [6]-[7]. Using computers in a classroom is believed to lead to more positive attitudes in students, because computers can do so many new things so quickly, so carefully, and because many students prefer using computers. There is little research, however, to support such claims. The limited research available suggests that computers can lead to more positive attitudes in some groups of students (males, younger students). Although the importance of hands-on labs to the science curriculum cannot be denied, [19], cites several advantages of computer simulations compared to laboratory activities. First, there appear to be important pedagogical advantages of using computer simulations in the classroom. Second, the purchase, maintenance, and update of lab equipment is often more expensive than computer hardware and software. Also, there is no concern

for students' physical safety in this learning environment. [36], discuss the instructional use and sequencing of computer simulation and its effect on students' cognitive processes. The sequence in which learning occurs influences the stability of cognitive structures [4]. New knowledge is made meaningful by relating it to prior knowledge and optimization of prior knowledge is done through sequencing. According to [20], simulations used prior to formal instruction build intuition and alert the student to the overall nature of the process. When used after formal instruction, the program offers the student an opportunity to apply the learned material.

There is evidence that simulations enhance students' problem solving skills by giving them an opportunity to practice and refine their higher-order thinking strategies [29]. Computer simulations were found to be very effective in stimulating environmental problem solving by community college students [18]. In particular, computer simulation exercises based on the guided discovery learning theory can be designed to provide motivation, expose misconceptions and areas of knowledge deficiency, integrate information, and enhance transfer of learning [27]. In three studies, students using the guided version of computer simulation surpassed unguided students on tests of scientific thinking and a test of critical thinking [35]. As a result of implementing properly designed simulation activities, the role of the teacher changes from a mere transmitter of information to a facilitator of higher-order thinking skills [38]. According to [27], simulations are seen as a powerful tool to teach not only the content but also thinking or reasoning skills that are necessary to solve problems in the real world.

The Experimental Design

At first the investigator has diagnose the learner's difficulty in performing the experiments with the help of diagnostic test. An achievement test was developed (covering theoretical aspects of these experiments) for examining change in the level of knowledge in Electronics (theory concepts).

The competency of performing the experiment was examined with the help of competency test on spot observation of student (Checklist), while performing the experiment. Their change in attitude was reflected with the

help of an attitude scale to be given before and after learning with the help of proposed Computer software support.

Learner's opinion about Computer software support was assessed with the help of opinion scale, developed by the investigator.

In the conventional laboratory, the students were given a lab manual which they had to read prior to starting the laboratory. From survey results, students often found it difficult with this method to understand what they had to do or how to find the result. The introduction of a virtual instrument for the laboratory experiments allowed the possibility of guiding the student through the operation of the experimental apparatus and the collection of the required data. The first ten experiments for which computer software were developed were used to aid the learning process.

The investigator developed the software using "mixed" design methodology. The programme modules were developed using Visual Basic 6.0, Visual C++, Multisim-8, LAB-VIEW-9 and SPICE programming language in Window 2007 environment. It provides multimedia presentation platform to attract the sense of learner for easy and happy learning. The investigator had seen that the frames were unambiguous, brief, simple and straightforward. The detail frame design is given in the Figure 1(a-g). An associated instrumentation, have been piloted with over 150 undergraduate Electronics science students affiliated to Sant Gadge Baba Amravati University, Amravati.. The design of the Computer Software for each of these



Figure 1.(a) Front panel of screen

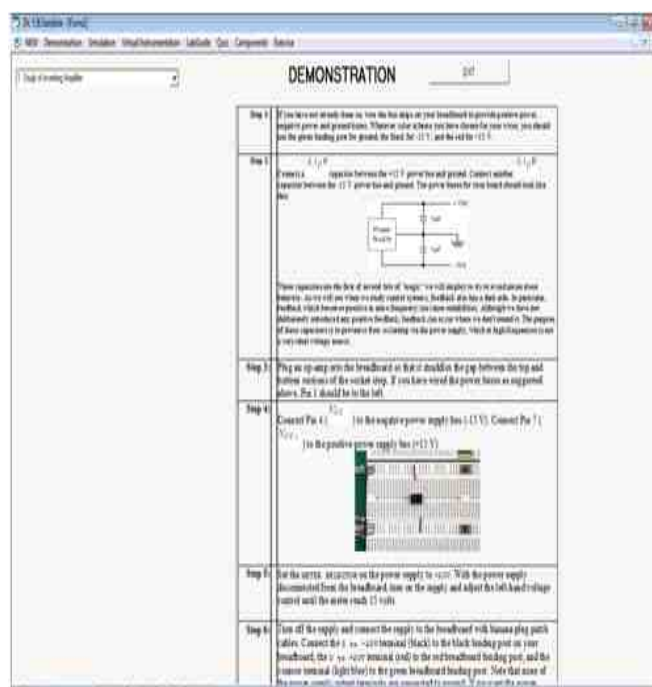


Figure 1. (b) Demonstation module



(c) Electronics Components and Instrumentation module

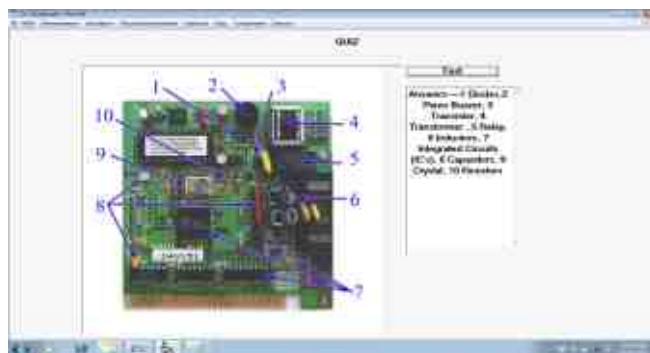


Figure 1. (d) Quiz Module

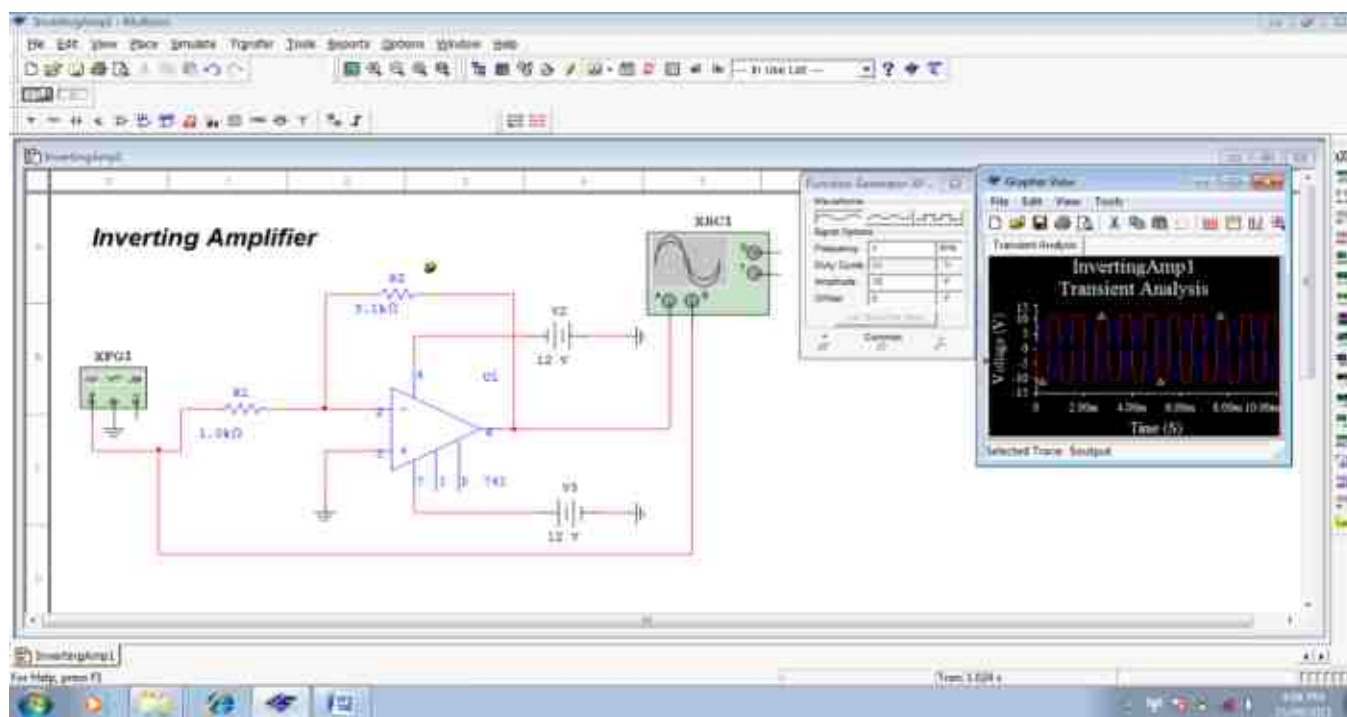


Figure 1. (e) Simulation Module

experiments was divided along pedagogical lines into three sections which are presented consecutively to the students:

Introduction

In this section, the students were given an overview of the

experiment to be undertaken, an animation showing how it worked, what was being measured and how it related to real applications.

Procedure and Data logging

In this part of the experiment students perform the

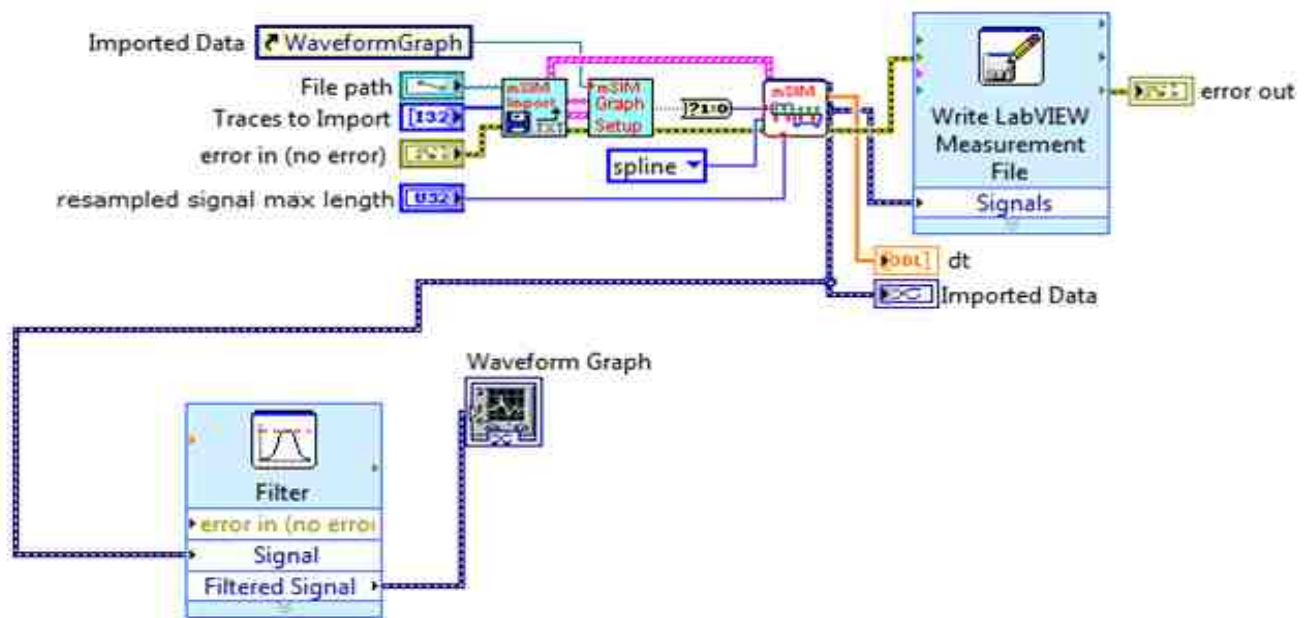


Figure 1. (f) Virtual Instrumentation module

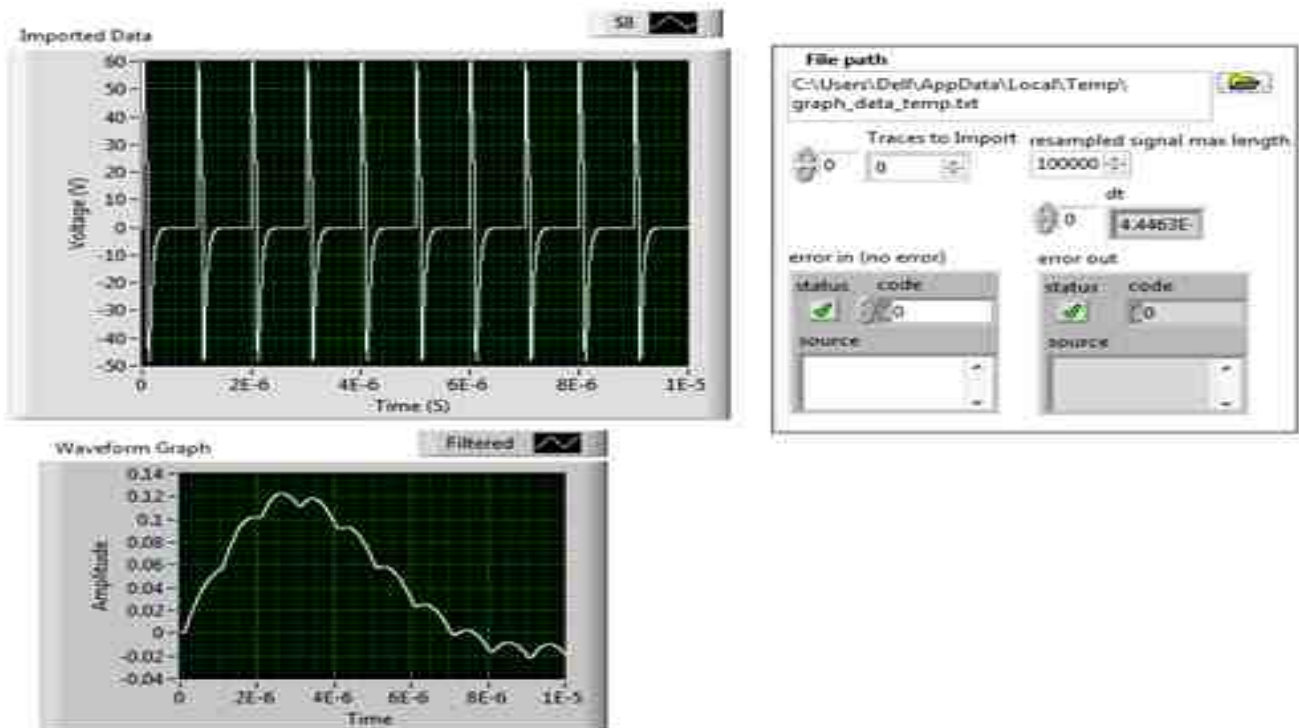


Figure 1. (g) Virtual Instrumentation GUI

Figure 1(a-g). GUI for Software

experiment and see the data logged and graphed on the PC as they progress through the experiment.

Theory and Calculations

In this section, the students work through their calculations

manually and calculate the result being sought from the experiment. They then enter their own values into the computer and receive immediate feedback of how these compare to the automatically calculated values from the Virtual Instrumentation and simulation techniques.

Result and Discussion

Software Tryout

The questionnaire was designed by the investigator to evaluate the quality of computer software program. This questionnaire contains 13 statements which refer to the technical aspects of the software. Their aim was to evaluate its technical adequacy to the learning objectives of the program. They deal mainly with questions related to the general structure of the product navigation, interactivity, design and other aspects that can favour or hinder the learning process. Overall 27 statements refer to curricular design aspects, usefulness and intend to evaluate the integration capacity of the program in the learning process of an electronics practical.

Responses of students were five-point scale. The 45 students, offering electronics subject at B.Sc. level were

selected randomly for this pilot. The students were divided into three batches. Initially the investigator demonstrated the each module of the software using LAN for each batch and they asked to operate the each module of the software freely. Finally the questionnaire was given to every student and they asked to write '1' for very bad or NO, '2' for bad or sometimes, '3' for acceptable or average, '4' for good or almost always and '5' for very good or Yes. The students who respond either 4 or 5 were grouped together which indicated the good quality of computer software. On the other hand the students who responded either 3, 2 or 1 are grouped together which indicated the poor quality of software and requires modifications. It was later on converted into a percentage. The consolidated list of percentage for every statements was given in Table 1.

From the analysis of pilot it was found that the development

Item no	Statement	% of positive response	% of negative response
A	<i>Technical-Instructive Adaptation :Interface Design (Screen design)</i>		
1	The quantity of colour on screen is adequate for the sort of information contained	84.44 %	15.56 %
2	The quantity of the images is adequate for the sort of information contained	77.78 %	22.22 %
3	The sound quality level is adequate for the sort of information transmitted	71.11 %	28.89 %
4	The quantity of graphics and images is adequate for the sort of information transmitted	82.22 %	17.78 %
5	The resolution of graphic and images is adequate for the sort of information transmitted	82.22 %	17.78 %
6	The text presentation on screen is adequate for the information transmitted, Access and control of the information	97.78 %	2.22 %
7	The student has control over different parameters of presentation (colour, sound level, etc.)	82.22 %	17.78 %
8	The program facilitates the paper printing of selected information by the student	95.56 %	4.44 %
9	The program facilitates the navigation through the contents	88.89 %	11.11 %
10	The program gives the student the possibility of modifying the information contained.	84.44 %	15.56 %
11	The interaction tools (buttons, menu, commands) facilitate the learning process	86.67 %	13.33 %
12	The program, in general, is easy to use	88.89 %	11.11 %
13	It is easy for the student to learn how to use the program	88.89 %	11.11 %
14	The running of the program is adequate (there are no bugs which block it)	86.67 %	8.89 %
B	<i>2.-Didactic or Curricular Adaptation</i>		
B1	<i>Learning contents</i>		
15	Are clearly presented	93.33 %	6.67 %
16	Emphasize the most important things	77.78 %	22.22 %
17	Are sequenced	93.33 %	6.67 %
18	The information is updated	88.89 %	11.11 %
19	Are enough to achieve the objectives	80.00 %	20.00 %
20	Are beneficial to the improvement of attitudes	91.11 %	8.89 %
21	Are extra-laboratory activities	91.11 %	8.89 %
22	Are free of grammar or spelling errors	95.56 %	4.44 %
B2	<i>Learning activities</i>		
23	Require different levels of mastery	8.89 %	91.11 %

Table 1. Analysis Of Computer Software Tryout (conti..)

Item no	Statement	% of positive response	% of negative response
24	Follow a logical sequence in relation to the objectives	84.44 %	15.56 %
25	The number of different activities is enough	80.00 %	20.00 %
26	Allow different tries for answering	91.11 %	8.89 %
27	Examples of the activities to be done are shown	93.33 %	6.67 %
28	Examples are clear and adequate	93.33 %	6.67 %
B3	<i>Evaluation</i>		
29	The program is constantly evaluating the student's output	84.44 %	15.56 %
30	Shows the student the errors he/she has made	82.22 %	17.78 %
31	Provides specific help for the student's errors	91.11 %	8.89 %
32	The feed-back is immediate	88.89 %	11.11 %
33	The feed-back is motivating for the student	86.67 %	13.33 %
34	The feed-back provides clear and significant information	88.89 %	11.11 %
35	Facilitates self-correction	86.67 %	13.33 %
36	Constantly informs the student about his/her output	82.22 %	17.78 %
B4	<i>Motivation</i>		
37	The program increases the active involvement of the student on the laboratory task	91.11 %	8.89 %
38	Students show a better interest in learning practical	93.33 %	6.67 %
C	<i>Usefulness</i>		
39	Use it as self-instruction material	88.89 %	11.11 %
40	Use it as complementary laboratory material	68.89 %	31.11 %
41	The program makes it possible for the students to work in groups of two or three	71.11 %	28.89 %

Table 1. Analysis of computer software tryout

of computer software programme for laboratory communication was very good.

Finally, acceptance testing was performed to demonstrate to the students, teachers and experts in electronics and computer field, on the real life data of the practical.

Opinion Scale

The investigator used opinionnaire to collect learner's opinion regarding Computer software support. This opinionnaire was containing 39 items related to various educational aspects. The overall analysis of data collected with the help of opinionnaire is given below.

- The experimental group students were of opinion that the computer software support for laboratory work was relevant to the objectives of laboratory experiment. According to 78% of students of FY B.Sc., 70% of students of SY B.Sc and 74% of students of TY B.Sc., the Computer Software support was relevant to the objectives of Electronics experiments.
- About the implementation of software, According to 88% of the students of FY B.Sc, 80% of students of SY

B.Sc and 90% of students of TY B.Sc., The experiments presented in an interesting manner. According to 100 % of the students of FY B.Sc., SY B.Sc and TY B.Sc., what is required in the write-up of an experiment was clear. the theory behind the experiments was clearly presented. According to 96% of the students of FY B.Sc., 90% of the students of SY B.Sc and TY B.Sc, The laboratory demonstration, experimental techniques and write-up were all interlinked. According to 80% of the students of FY B.Sc and TY B Sc, 82% of the students of SY B.Sc, The instructions provided with the software were adequate. According to 20% of the students of FY B.Sc, SY B.Sc & TY B.Sc, the content of the software assume too much prior knowledge about computer. According to 80% of the students, the instructions provided with the software were adequate.

- According to 88 % of the students of FY B.Sc., 80% of the students of SY B.Sc., and 90% of the students of TY B.Sc, The software was interested in their progress in Electronics.
- According to 94% of the students of FY B.Sc., 84% of

the students of SY B.Sc., and 90% of the students of TY B.Sc, the laboratory demonstration contained instructions that were easy to follow.

- According to 90% of the students of FY B.Sc., 92% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the simulation module made them feel, to have ability to continue in Electronics science.
- According to 90% of the students of FY B.Sc., 80% of the students of SY B.Sc., and 90% of the students of TY B.Sc, time in practical was spent effectively.
- According to 92% of the students of FY B.Sc., 92% of the students of SY B.Sc., and 96% of the students of TY B.Sc, the software stimulated their interest in the subject area.
- According to 96% of the students of FY B.Sc., 90% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software did his share in helping them to learn electronics experiment.
- According to 84% of the students of FY B.Sc., 90% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software was user friendly.
- According to 80% of the students of FY B.Sc., 90% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software is fully self instructional.
- According to 94% of the students of FY B.Sc., 94% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the interactive nature of the software made the experiment more interesting.
- According to 96% of the students of FY B.Sc., 98% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software enhanced their enjoyment of learning about electronics subject.
- According to 80% of the students of FY B.Sc., 80% of the students of SY B.Sc., and 80% of the students of TY B.Sc, the software helped make the experiment concepts easy to understand.
- According to 96% of the students of FY B.Sc., SY B.Sc., and TY B.Sc, when needed, they found the written instructions & simulation to be helpful
- According to 84% of the students of FY B.Sc., 80% of the students of SY B.Sc., and 80% of the students of TY B.Sc, the software help electronics practical learning.
- According to 96% of the students of FY B.Sc., 98% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software add value over conventional practical methods.
- According to 80% of the students of FY B.Sc., 78% of the students of SY B.Sc., and 80% of the students of TY B.Sc, the software meet the needs for their electronics practical.
- According to 82% of the students of FY B.Sc., 90% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software make the student think about subject matter.
- According to 90% of the students of FY B.Sc., 96% of the students of SY B.Sc., and 96% of the students of TY B.Sc, the software support activities that is otherwise difficult to learn.
- According to 90% of the students of FY B.Sc., 94% of the students of SY B.Sc., and 96% of the students of TY B.Sc, the software have the potential to add anything new to the students learning experience that traditional practical method would not provide.
- According to 76% of the students of FY B.Sc., 70% of the students of SY B.Sc., and 70% of the students of TY B.Sc, students will learn by using software.
- According to 88% of the students of FY B.Sc., 90% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software would be recommended for teaching students about electronics practical.
- According to 92% of the students of FY B.Sc., 96% of the students of SY B.Sc., and 96% of the students of TY B.Sc, the tasks in the software engage the students.
- According to 92% of the students of FY B.Sc., 92% of the students of SY B.Sc., and 90% of the students of TY B.Sc, the software can test out their ideas and receive feedback-using software.
- According to FY B.Sc. Students, The Overall rating of the software: 30% rated, outstanding (Among the top10%), 50% rated, excellent (Among the top 30%), 20% rated About Average (Middle 40%).
- According to SY B.Sc Students The Overall rating of the

software: 40% rated, Outstanding (Among the top10%), 40% rated, excellent (Among the top 30%), 20% rated About Average (Middle 40%).

- According to TY B.Sc Students The Overall rating of the software: 36% rated, Outstanding (Among the top10%), 44% rated, excellent (Among the top 30%), 20% rated About Average (Middle 40%).

Conclusion

In a lesson without simulations or VIs, the learner deals with the lesson and the real world in two separate moments and the lesson can just present a picture of the real world. On the opposite, according to the VI model, the learner can deal directly with the real world. The main goals of the lesson become to guide the execution of the experiment, to give on-line instructions and information about the involved subjects and to stimulate the participation of the student. The execution of virtual experiments requires the creation of interfaces which, in the case of Science applications, consist of multimedia simulation for the communication between the learners' commands and the target system

The Computer software support was found very effective in communicating laboratory activities than the traditional method. However, there were not much difference in the achievement and competency of student in experimental and control group. Computer software support activities can be used as an educational alternative to help motivate students into self-discovery and develop their practical skills. The laboratory activity can then be focused on the actual transfer of knowledge. This strategy helps to improve the effectiveness and efficiency of teaching-learning process. While communication science subject through distance education mode, is necessary to arrange contact programme or a laboratory workshop where the demonstration of an experiments will be given by teacher and then only students can perform the experiments.

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